CHROMOSOME NUMBERS OF TREE SPECIES OF A LOWLAND TROPICAL COMMUNITY

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CHROMOSOMAL CYTOLOGY HAS PLAYED a significant role in elucidating cytogenetic relationships among higher plants of the North Temperate Zone. However, for plants of the tropics, especially trees, even the chromosome numbers are not known for most species. Cytological data are particularly scarce for trees of the neotropics since almost all available data are from Asiatic or African species (see for example, Mangenot & Mangenot, 1962; Mehra & Bawa, 1969; Styles & Vosa, 1971; Hans, 1972).

This paper reports chromosome numbers of tree species of a lowland tropical semideciduous forest in Costa Rica. A total of 66 species in 56 genera from 32 families were investigated; chromosome counts for 45 species and 16 genera were made for the first time.

MATERIAL AND METHODS

Material for chromosomal studies was collected from Hacienda Ciruelas, 5 km. northwest of Bagaces and Hacienda La Pacifica, 5 km. northwest of Cañas in Guanacaste Province, Costa Rica. The vegetation of these sites has been described in detail by Holdridge *et al.* (1971) and Daubenmire (1972), and need not be elaborated upon here.

Floral buds were fixed in acetic alcohol (1:3), and after 24 to 28 hours transferred to 70 per cent alcohol. The buds were then stored at 0° C until the time of cytological examination. Standard cytological techniques (Sharma & Sharma, 1965) were employed for the study of chromosomes. In most species observations were made of material from two or three individuals.

Voucher specimens have been deposited in the Herbarium, Missouri Botanical Garden, St. Louis, Missouri, U.S.A. (MO).

RESULTS AND INTERPRETATION

The results are summarized in TABLE 1 in which are listed chromosome numbers together with ploidy level and previous cytological reports, if any, for all investigated taxa.

A detailed interpretation of chromosome numbers in each family must await accumulation of more data; however, numbers of a few taxa merit some comments which are presented below:

LEGUMINOSAE

The present report of $n = 11$ for *Andira inermis*, and $n = 10$ for

Piscidia carthagenensis differs from $n = 10$ and $n = 11$ reported for those species, respectively, by Atchison (1951).

MALPIGHIACEAE

The current finding of $n = 12$ for *Byrsonima crassifolia* from several different localities is at variance with $2n = 20$ reported for this species by Nanda (1962). The same is true for *Malpighia glabra* in which the gametic number was observed to be $n = 10$ in contrast to $2n = 40$ reported by Pal (1964).

Kyhos (1966) has found $2n = 12$ in *Galphimia glauca*. It is, therefore, likely that $x = 12$, reported in several taxa of Malpighiaceae, is of polyploid derivation.

BOMBACACEAE

The family is characterized by the presence of high chromosome numbers. With the exception of *Durio zibethinus* ($n = 28$) all other taxa have $n = 36$ or more. The present report of $n = 45$ for *Ochroma pyramidale* differs from $n = 36$, 39, and 44 reported for this species under the name of *O. lagopus* by Baker and Baker (1968). In addition, *Bombacopsis quinata* was observed to have $n = 46$, but Baker and Baker (l.c.) recorded $n = 36$ for this species. The infraspecific variation in chromosome numbers also exists in several other taxa of the family. The variation in chromosome numbers could be, a) due to errors in the counting of chromosomes which could result from incomplete separation of a large number of chromosomes at metaphase or, b) due to the presence of accessory chromosomes. The first possibility is minimized by the fact that counts by Baker and Baker and those reported here are based on observations of many cells from several individuals. The second possibility has been discussed by Baker and Baker, but the presence of accessory chromosomes remains to be established. The present data do not indicate the occurrence of accessory chromosomes because the same number of bivalents was observed in each cell. Clearly, more intensive cytological work on the family is needed to establish the true nature of chromosomal variability.

The basic number in the family is probably $x = 9$, and the whole assemblage appears to be an ancient polyploid series.

BORAGINACEAE

The genus *Cordia* shows remarkable variation in chromosome numbers at the interspecific level; such variation is uncommon in tropical woody genera. According to Britton (1951), the base number of the genus is $x = 8$ because two species from India are reported to have $2n = 16$.

The present report of $n = 15$ for *C. alliodora* from several individuals contrasts sharply with $2n = 72$ found by Britton (1951) in this species. I have no doubt about the correct identification of my voucher specimens, but I have been unable to check Britton's material. Since *C. alliodora* is a species of major importance to forestry in Central America, more intensive investigations are needed to detect the pattern of intraspecific variability in chromosome numbers, if it exists.

DISCUSSION

A common feature that most trees share is the high basic number: in 48 out of 56 genera the basic chromosome number is $x = 11$ or more. The same is true for tropical woody genera investigated from Africa and Asia (Mangenot & Mangenot, 1962, Mehra & Bawa, 1969). To the extent that the recombination index is a function of chromosome number, the high chromosome number must lead to an increase in the number of recombinants among the gametes of an individual (Lewis & John, 1963). The obligatory outcrossing mechanisms that characterize a majority of trees mentioned in this report (Bawa, 1973) further increase the number of recombinants but now among the zygotes. Thus both the meiotic system and the breeding system in tropical trees supplement each other in increasing the array of genotypes that result from a given reproductive cycle. It is beyond the scope of this paper to deal with the significance of the vast recombination potential of the genetic systems that appear to characterize most tropical trees investigated so far, but it needs to be emphasized that most tropical tree species are not characterized by the presence of a genetic system that conserves variation as is often assumed (see for example Catinot, 1972, Fedorov, 1966).

It is not only the tropical woody genera that have high basic numbers; genera in some herbaceous families of the tropics such as Bromeliaceae, Commelinaceae, and Orchidaceae also have basic numbers that exceed $x = 11$ (cf. Stebbins, 1971). However, in those families that contain both herbaceous and woody taxa as, for example, the Leguminosae which are cytologically well known, the former have a lower basic number than the latter (Atchison, 1951; Solbrig, 1972). Grant (1963) has also pointed out a similar difference in the basic numbers of herbaceous and woody taxa of flowering plants in general.

According to Ehrendorfer *et al.* (1968), the numbers higher than $x = 11$ in woody angiosperms are probably of polyploid origin. If this assumption is correct, polyploids among the Costa Rican tree species amount to 70 per cent. However, if all chromosome numbers are considered as diploid unless they are multiples of lower numbers found in related genera, the frequency of polyploids is reduced to about 50 per cent. The true percentage of polyploids probably lies between these two extremes. Since one third to one half of all angiosperms are presumed to be polyploid (Hanelt, 1966; Löve & Löve, 1967; Grant, 1971; Stebbins, 1971; de Wet, 1971), the frequency of polyploidy among tropical trees is higher than in flowering plants as a whole.

Although the frequency of polyploids among tropical woody taxa is high, polyploid series within genera are not common (Stebbins, 1971). As shown in TABLE II most genera found in the semideciduous forest have evolved at either the diploid or at the polyploid level: genera which contain diploid species have few or no polyploids and those which contain polyploid species have few or no diploids. Furthermore, in the latter

TABLE I: **Summary of cytological results.**

NAME	VOUCHER NUMBER	GAMETIC CHROMOSOME NUMBER	PLOIDY LEVEL	PREVIOUS REPORT
FAGACEAE				
***Quercus oleoides* Cham. & Schlecht.	119	12	diploid	
ULMACEAE				
***Trema micrantha* (L.) Blume	252	10	diploid	
MORACEAE				
Cecropia peltata L.	265	14	diploid	$2n = 28$: Krause, 1931
PROTEACEAE				
**Roupala complicata* HBK.	269	14	tetraploid	
OLACACEAE				
**Ximenia americana* L.	169	13	?	
POLYGONACEAE				
***Triplaris americana* L.	239	11	diploid	
ANNONACEAE				
***Annona purpurea* Moc. & Sessé	247	7	diploid	
***A. reticulata* L.	202	7	diploid	
**Sapranthus palanga* R. E. Fries	142	9	diploid	
LAURACEAE				
***Ocotea veraguensis* Mez	127	12	diploid	

TABLE I: Summary of cytological results. (*Continued*)

NAME	VOUCHER NUMBER	GAMETIC CHROMOSOME NUMBER	PLOIDY LEVEL	PREVIOUS REPORT
CAPPARACEAE				
***Crataeva tapia* L.	240	13	?	
LEGUMINOSAE: Mimosoideae				
Enterolobium cyclocarpum (Jacq.) Griseb.	170	13	diploid	$2n = 26$: Atchison, 1951
***Pithecolobium racemiflorum* Donn. Smith	270	13	diploid	
P. saman (Jacq.) Benth.	195	13	diploid	$2n = 26$: Atchison, 1951 Simmonds, 1954
LEGUMINOSAE: Caesalpinioideae				
Cassia biflora L.	165	14	tetraploid	$2n = 28$: Irwin & Turner, 1960
Hymenaea courbaril L.	168	12	diploid	$2n = 24$: Atchison, 1954; Berger *et al.*, 1958
LEGUMINOSAE: Papilionoideae				
Andira inermis (Swartz) HBK.	129	11	diploid	$2n = 20$: Atchison, 1951
***Dalbergia retusa* Hemsl.	191	10	diploid	
***Lonchocarpus costaricensis* (Donn. Smith) Pittier	184	11	diploid	
***L. eriocarinalis* Micheli	190	11	diploid	
***L. guatemalensis* Benth.	261	11	diploid	
***L. nitidus* (Vog.) Benth. complex	216	11	diploid	
Piscidia carthagenensis Jacq.	264	10	diploid	$2n = 22$: Atchison, 1951
***Platymiscium pleiostachyum* Donn. Smith	271	9	diploid	
***Pterocarpus rohrii* Vahl	125	10	diploid	
SIMAROUBACEAE				
**Simarouba glauca* DC.	110	16	tetraploid	
BURSERACEAE				
***Bursera simarouba* (L.) Sarg.	268	12	diploid	
***B. tomentosa* (Jacq.) Tr. & Planch.	211	12	diploid	
MELIACEAE				
***Trichilia arborea* C. DC.	272	25	tetraploid	
MALPIGHIACEAE				
Byrsonima crassifolia (L.) HBK.	118	12	tetraploid?	$2n = 20$: Nanda, 1962
Malpighia glabra L.	163	10	diploid?	$2n = 24$: Fouët, 1966; $2n = 40$: Pal, 1964
EUPHORBIACEAE				
**Bernardia nicaraguensis* Standl. & L. O. Williams	177	26	tetraploid	
Garcia nutans Rohr	259	33	hexaploid	$2n = 36$: Miller & Webster, 1966
Hura crepitans L.	221	22	tetraploid	$2n = 36$: Miège, 1962; $2n = 44$: Datta, 1967
ANACARDIACEAE				
Spondias mombin L.	183	16	tetraploid	$2n = 32$: Simmonds, 1954

TABLE I: Summary of cytological results. (*Continued*)

NAME	VOUCHER NUMBER	GAMETIC CHROMOSOME NUMBER	PLOIDY LEVEL	PREVIOUS REPORT
HIPPOCRATEACEAE				
**Hemiangium excelsum* (HBK.) A. C. Smith	156	30	tetraploid	
SAPINDACEAE				
**Allophylus occidentalis* (Swartz) Radlk.	210	14	tetraploid	
**Cupania americana* L.	108	16	tetraploid	
**Thouinidium decandrum* (Humb. & Bonpl.) Radlk.	133	ca. 14	tetraploid	
ELAEOCARPACEAE				
**Muntingia calabura* L.	120	14	tetraploid	
**Sloanea terniflora* (Moc. & Sessé) Standl.	149	13	tetraploid	
TILIACEAE				
**Apeiba tibourbou* Aubl.	205	18	tetraploid	
Luehea candida (Moc. & Sessé) Mart. & Zucc.	198	18	tetraploid	$2n = 36$: Gadella *et al.*, 1969
BOMBACACEAE				
Bombacopsis quinata (Jacq.) Dugand	106	46	decaploid?	$2n = 72$: Baker & Baker, 1968
Ochroma pyramidale (Cav. ex Lam.) Urban	145	45	decaploid?	$2n = 72, 78, 88$: Baker & Baker, 1968
***Pseudobombax septenatum* (Jacq.) Dugand	141	ca. 44	decaploid?	
STERCULIACEAE				
Guazuma tomentosa HBK.	132	8	diploid	$2n = 16$: Youngman, 1931
***Sterculia apetala* (Jacq.) Karst.	187	20	tetraploid	
DILLENIACEAE				
**Curatella americana* L.	116	ca. 12	diploid	
OCHNACEAE				
***Ouratea wrightii* Riley	185	13	diploid	
MYRSINACEAE				
***Ardisia revoluta* HBK.	162	23	tetraploid	
THEOPHRASTACEAE				
Jacquinia aurantiaca Ait.	111	18	tetraploid	$2n = 36$: Faure, 1968
SAPOTACEAE				
***Manilkara zapota* (L.) P. van Royen	214	12	diploid	
**Mastichodendron capiri* Cronquist var. *tempisque* (Pittier) Cronquist	146	11	diploid	
EBENACEAE				
***Diospyros nicaraguensis* Standl.	204	15	diploid	
STYRACACEAE				
***Styrax argenteus* Presl	114	8	diploid	

TABLE I: Summary of cytological results. (*Continued*)

NAME	VOUCHER NUMBER	GAMETIC CHROMOSOME NUMBER	PLOIDY LEVEL	PREVIOUS REPORT
APOCYNACEAE				
Plumeria rubra L. var. *acutifolia* Poir.	167	18	tetraploid	$2n = 36$: Singh, 1954; Tapadar & Sen, 1960; Nanda, 1962
**Stemmadenia donnell-smithii* (Rose) Woodson	176	19	tetraploid	
BORAGINACEAE				
**Bourreria quirosii* Standl.	148	19	?	
Cordia alliodora (Ruiz & Pav.) Cham.	105	15	tetraploid	$2n = 72$: Britton, 1951
***C. collococca* Sond.	199	14	tetraploid	
***C. dentata* Poir.	229	24	hexaploid	
***C. panamensis* Riley	217	14	tetraploid	
***C. inerma* (Mill.) Johnston	223	14	tetraploid	
BIGNONIACEAE				
Tabebuia rosea (Bertol.) DC.	126	20	diploid	$2n = 40$: Venkatasubban, 1944
T. palmeri Rose	273	20	diploid	$2n = 40$: Pathak *et al.*, 1949

* Genera investigated for the first time.
** Species investigated for the first time.

TABLE II: **Frequency of polyploid species in woody genera of a lowland tropical semideciduous forest in Costa Rica.**[1,2]

NAME	BASIC NUMBER	NUMBER OF DIPLOID SPECIES	NUMBER OF POLYPLOID SPECIES
Piper	13	7	6
Annona	7	7	2
Bauhinia	7	—	15
Cassia	7	31	84
Caesalpinia	12	20	—
Acacia	13	66	27
Albizia	13	13	2
Pithecolobium	13	8	1
Lonchocarpus	11	13	1
Pterocarpus	11	7	2
Zanthoxylum	9?	—	6
Trichilia	14	1	8
Cedrela	12?	—	8
Malpighia	10	4	1
Margaritaria	7	2	19
Sterculia	10	—	9
Ouratea	12	12	1
Eugenia	11	8	7
Ardisia	—	1	6
Diospyros	15	13	6
Plumeria	9	—	5
Cordia	8	—	15
Tabebuia	20	10	—
Psychotria	11	16	2

[1] Based on chromosome counts reported in Bolkhovskikh *et al.* (1969).
[2] Only those genera in which chromosome counts for more than five species are known are tabulated.

group of genera, within a genus most species usually have the same ploidy level.

Polyploid series within species are also not common, but rarely have tropical tree species been subjected to the sort of intensive studies that are necessary to reveal intraspecific variability in chromosome numbers; in most species investigated to date, chromosome counts have been based on the study of few individuals. Among species mentioned in this report, *Cordia alliodora*, *Ochroma pyramidale*, *Bombacopsis quinata* and *Pseudobombax septenatum* appear to have polyploid series (TABLE I). The reasons for the low frequency of polyploid series have been pointed out by Stebbins (1971), and need not be elaborated upon here.

SUMMARY

This paper reports chromosome numbers of tree species of a lowland tropical semideciduous forest in Costa Rica. A total of 66 species in

56 genera from 32 families were investigated, chromosome counts for 45 species and 16 genera were made for the first time. A common feature of most species is the high basic number; in 48 out of 56 genera, the basic number is $x = 11$ or more. Such numbers are probably of polyploid derivation. However, although the frequency of polyploids among tropical woody taxa is high, polyploid series within genera and species are rare.

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